

### What is shaken baby syndrome?

Shaken baby syndrome is a term used to describe the constellation of signs and symptoms resulting from violent shaking or shaking and impacting of the head of an infant or small child. The degree of brain damage depends on the amount and duration of the shaking and the forces involved in impact of the head. Signs and symptoms range on a spectrum of neurological alterations from minor (irritability, lethargy, tremors, vomiting) to major (seizures, coma, stupor, death). These neurological changes are due to destruction of brain cells secondary to trauma, lack of oxygen to the brain cells, and swelling of the brain. Extensive retinal hemorrhages in one or both eyes are found in the vast majority of these cases. The classic triad of subdural hematoma, brain swelling and retinal hemorrhages are accompanied in some, but not all, cases by bruising of the part of the body used as a "handle" for shaking. Fractures of the long bones and/or of the ribs may also be seen in some cases. In many cases, however, there is no external evidence of trauma either to the head or the body. *(Definition provided by Robert Reece, M.D. Dr. Reece is a clinical professor of Pediatrics at the Tufts University School of Medicine.)*

Approximately 20% of cases are fatal in the first few days after injury and the majority of the survivors are left with handicaps ranging from mild - learning disorders, behavioral changes - to moderate and severe, such as profound mental and developmental retardation, paralysis, blindness, inability to eat or exist in a permanent vegetative state.

In a response provided by Dr. John Lancon, he defined shaken baby syndrome as the constellation of non-accidental intracranial and ocular hemorrhages occurring in infants and young children. Other injuries, including cutaneous bruises, lacerations, burns, parenchymal brain injuries, rib fractures, extremity fractures, and injuries to various internal organs may be seen in the setting of shaken baby syndrome, but are not required for diagnosis. Some experts have suggested changing the name of the syndrome to shaken impact syndrome to emphasize the importance of cranial impact in the genesis of the severe brain injury seen in some victims of shaken baby syndrome.

### What are subdural hemorrhages, subarachnoid and epidural hemorrhages and the differences between them?

Epidural, subdural, and subarachnoid hemorrhages are best understood by reviewing the anatomy of the meninges (membrane coverings of the brain):

The meninges are divided into three layers: the dura mater, arachnoid, and pia mater. The outer layer, the dura mater, lines the inner surfaces of the skull and forms several reflections that partially separate the cerebral hemispheres along the midline (interhemispheric fissure) and the cerebrum from the cerebellum. The dura mater is rather firmly adherent to the skull, particularly at the junctions (cranial sutures) of the various bones which comprise the skull. The potential space between the skull and the dura mater is referred to as the epidural space. A hemorrhage into this space is referred to as an epidural hemorrhage. These hemorrhages are usually the result of a tear in a meningeal artery.

The middle layer of the meninges is the arachnoid. It is a thin membrane likened in appearance to a spider's web. Under normal conditions, the arachnoid is attached to the overlying dura. The potential space between the dura mater and the arachnoid's is the subdural space. A hemorrhage into this space is referred to as a subdural hemorrhage. These hemorrhages are usually the result of a tear in one of the small veins which traverses the space between the brain and the dura mater (bridging veins).

Finally, the pia mater is the innermost layer. It is delicate and intimately adherent to the surface of the brain. The space between the arachnoid and the pia mater is the subarachnoid space. A hemorrhage into this space is referred to as a subarachnoid hemorrhage.

Epidural, subdural, and subarachnoid hemorrhages are sometimes referred to as extra-axial hemorrhages, indicating that they occur outside the substance of the brain. Although all three types of hemorrhage may occur with non-accidental trauma, the classic intracranial hemorrhage seen in Shaken Baby Syndrome is the subdural hemorrhage. In this setting, the subdural hemorrhage is often bilateral or located in the posterior interhemispheric fissure. *(Answer provided by John Lancon, M.D., Assistant Professor of Neurosurgery at the University of Mississippi Medical Center, Jackson, MS.)*

### How much force is necessary to cause injuries in shaken baby syndrome? How many times do you have to shake an infant or young child to cause damage?

No firm answer exists as to the exact number of shakes necessary to create the clinical picture nor for how long a

person might typically shake a child in abusive circumstances.... Shaking probably lasts a maximum of 20 seconds or less. In most cases the period of shaking is 5 to 10 seconds. To cause brain damage sufficient to allow clinical detection of the syndrome, severe forces must be used. On mechanical/physiologic grounds and by experience with perpetrators who have been convicted or confessed to the shaking, it is clear that to lift an infant and shake requires an adult or an adult-sized person.

Alexander RC, Levitt CJ, Smith WL. *Abusive Head Trauma*. In: Reece RM, Ludwig S, eds. *Child Abuse: Medical Diagnosis and Management* 2nd ed. Philadelphia, Pa: Lippincott Williams & Wilkins; 2001:52.

### What is the retina of the eye?

As defined by Webster, the retina is the inner coat of the back of the eye, containing cells sensitive to light. Images formed on the retina by the lens of the eye are carried by the optic nerve to the brain.

### What are retinal hemorrhages and what is their relationship to shaken baby syndrome?

From Levin AV: Ocular Manifestations of Child Abuse in Reece RM and Child Abuse Medical Diagnosis and Management by Robert Reece, M.D. Ludwig- Retinal hemorrhages are common in abused children. Retinal hemorrhages are common in shaken infants with reports ranging from 30 to 100% depending on the population studied. Describing the retinal hemorrhages in terms of type, number and distribution is essential if one is to appreciate the specificity of any particular child's eye examination. A few intraretinal hemorrhages confined to the posterior pole may be very nonspecific and could result from numerous other causes. But the presence of massive retinal hemorrhage throughout the entire retina (subretinal, intraretinal, and preretinal) is virtually diagnostic of shaken baby syndrome, as it is very rare to see such a presentation of any other systemic or ocular disease that would not otherwise be easily distinguished by the presence of other supportive signs. Too often, in the medical literature and other settings, comments are made about the specificity or implications of "retinal hemorrhages". The use of this rather generic term is no more helpful in determining a diagnosis of accidental versus nonaccidental injury than is the use of the term "fracture" without describing the involved bone and type of fracture.

The nonophthalmologist is at a distinct disadvantage in achieving an adequate description of intraocular hemorrhage because of lack of routine exposure, failure to dilate the pupil pharmacologically, and the limitations of the direct ophthalmoscope, particularly in the awake and noncooperative infant. False-positive and false-negative examinations may occur; if documented in the medical record they may lead to confusing evidence in a legal proceeding. It is essential that ophthalmology consultation be obtained in all cases in which shaken baby syndrome is suspected, if not all cases of unexplained sudden infant death. Except in those cases where a child's pupils may be fixed and dilated because of imminent death, the pupils should always be pharmacologically dilated so that the entire retina may be viewed. If there are concerns about preserving pupillary activity for neurologic monitoring, options include the use of short-acting agents (phenylephrine, 2.5%; tropicamide, 1% ), which will wear off within 4 to 6 hours, dilating one pupil at a time, or if no other options exist, using small pupil indirect ophthalmoscopy. Ideally, the examination should be conducted within 24 hours of presentation or recognition of the possibility of nonaccidental injury. The ophthalmologist should be encouraged to write a descriptive note and perform retinal photography by using either a standard hand-held fundus camera, video indirect ophthalmoscopy, or the RetCam photographic unit. Such equipment is extremely costly and may not be available at many centers, but detailed drawings and scoring systems can also be useful.

One specific retinal abnormality, traumatic retinoschisis, is essential to recognize as it is highly specific for shaken baby syndrome and has never been described in any other condition of infants and young children in the shaken baby range. At these ages, the vitreous is quite firmly adherent to the macula and retinal blood vessels, much more so than in the adult. As a result, the shaking forces applied indirectly to the vitreous exert shearing tractional forces on the retina, in particular the macula, causing it to split its layers, forming a cystic cavity that may be partially or completely filled with blood. It also is important to avoid the common error in identifying these blood collections as "preretinal" or "subhyaloid" (between the vitreous and the retina). Recognition of traumatic retinoschisis is aided by the identification of hemorrhagic or hypopigmented circumlinear ridges or lines at the edges of the lesion. These demarcations also have been called paramacular folds. Schisis-like cavities also can form directly over blood vessels, although this is a less specific finding that may be mimicked by virtually any disorder in which a major vessel can have a local bleed (e.g., vasculitis, leukemia). The blood within a retinoschisis cavity may leak into the vitreous, making careful monitoring and follow-up essential.

Levin AV. *Ocular Manifestations of Child Abuse*. In: Reece RM, Ludwig S, eds. *Child Abuse: Medical Diagnosis and Management* 2nd ed. Philadelphia, Pa: Lippincott Williams & Wilkins; 2001:99-100.

## Medical Facts

*Information on this page is not intended to replace advice by a health care professional. If you are concerned about your child's health please consult a physician.*

### Abusive Head Trauma can be Difficult for Physicians to Recognize

Abusive head trauma is a dangerous form of child abuse. Head injury in infants and toddlers can be difficult to diagnose, as symptoms are often nonspecific. Vomiting, fever, irritability and lethargy are common symptoms of a host of diseases seen in children, including head trauma. When caretakers do not give a history of injury, and when the victim is pre-verbal, an abusive head injury can be mistakenly diagnosed as a less serious condition. We studied 173 cases of abusive head trauma in children less than 3 years old who were evaluated at the Childrens Hospital, Denver, Colorado, from 1990 through 1995. Since the mechanism of injury cannot always be accurately determined in child abuse cases, we studied children who had experienced shaking, impact to the head, or both.

The mean age of the 173 children was eight months. All of the children suffered serious head injuries. Thirty-one percent of the children had previously been seen by a physician who did not recognize the diagnosis of abusive head trauma. Many of the 54 children whose head injuries were missed were seen by doctors on multiple occasions after their injuries. For children whose head trauma was missed, the average length of time to diagnosis head trauma from the day of the first doctor visit was 7 days. When missed cases were compared to recognized cases, several factors were found to be significantly different.

Children with missed abusive head trauma were much younger than those in whom the diagnosis was recognized on the first physician visit. The mean age of the missed cases at the time of their first medical visit for head injury symptoms was 180 days. The mean age of the recognized cases was 278 days.

Abusive head trauma was missed significantly more often in children who were Caucasian than in children of minority races, and was more likely missed in families where both parents lived with the child. Not surprisingly, the severely injured children were more likely to be recognized as having head trauma at their first visit to the physician. At the first visit, children who were comatose, whose breathing was compromised, who were seizing or who had facial bruising were more likely to be accurately diagnosed.

We constructed a computer model based on the data to determine how likely a physician would be to recognize the correct diagnosis of abusive head trauma. We found that if a child had normal respirations, no seizures, no facial or scalp injury, and came from an intact family, the probability that abusive head trauma would be recognized was less than one in five.

We do not know how many cases of abusive head trauma are never detected. Parents who confess to shaking or hitting the heads of their children frequently report doing the same thing previously. In one of our study cases, an infant was hospitalized three times after violent shaking before someone witnessed the abuse. Infants have few ways to demonstrate illness or injury. Non-specific signs such as vomiting, fever and irritability are frequently seen in a myriad of conditions, including many minor illnesses. The difficulty, then, is to be able to tell when these signs and symptoms occurred because of serious head injuries.

Are missed cases of missed abusive head trauma inevitable? If a child's caretakers cannot or will not give an accurate history, making the correct diagnosis is extremely difficult. Physicians cannot obtain cranial CT scans on every infant and toddler who is present with vomiting, irritability and fever.

Based on this study and on our experience with these cases, we recommend the following suggestions to physicians to facilitate the diagnosis of abusive head trauma:

- Be alert for the presence of bruises or abrasions on the faces or heads of children presenting non-specific symptoms.
- When evaluating infants and toddlers with non-specific symptoms, such as vomiting, fever, or irritability, consider head trauma in the differential diagnosis. Perform a head-to-toe physical examination, check the fontanelles (soft spots) on the babies heads, measure the head size and be alert for signs of trauma.
- When doing a spinal tap, look for signs of previous bleeding or old blood in the spinal fluid.
- Pediatric radiologists should be consulted to interpret X-rays and head CTs in cases of suspected child abuse. More research should be done to find better ways of diagnosing head trauma in infants and young children. Education is also important. While it is difficult for physicians to detect all serious abusive head trauma in the clinical setting, an awareness of the signs and symptoms of abusive head trauma could increase the likelihood that more cases will be detected.

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#### **For further information please see:**

Jenny, C., Hymel, KP, Ritzen, A., Reinert, SE, Hay, TC. Abusive Head Trauma: An Analysis of Missed Cases, *Journal of the American Medical Association* 281:621-626, 1999.